# Northern Goshawk Surveys on the Kanuti National Wildlife Refuge, 2013

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## Introduction

We initiated a survey of Northern Goshawks (*Accipiter gentilis*) on Kanuti National Wildlife Refuge (KNWR) in 2011 and expanded it in 2012 (Craig and Spindler 2011, Craig et al. 2012). The purpose of the survey was to develop a method to monitor the abundance and distribution of nesting goshawks in Kanuti's remote setting using broadcast calls, a common survey technique in the coterminous United States. Goshawks are of particular interest because they are an apex predator about which very little is known on KNWR, or in the North American Arctic in general. Furthermore, goshawks usually nest in stands of large, mature trees that have a closed canopy (≥60% canopy cover) and an open understory (Squires and Reynolds 1997). Rupp and Springsteen (2009) have predicted that the incidence of wildfire on the Refuge will increase in the future because of climate change and this will change forest stand structure. Even in the absence of fire, the canopy closure in older white spruce (*Picea glauca*) stands will likely be reduced due to increasing temperature and concomitant disease-related mortalities (Glenn Juday,

pers. comm., Beck et al. 2011). As the size and characteristics of old growth timber patches change on KNWR, a reduction in suitable nesting habitat for Northern Goshawks may result.

In 2011 we surveyed approximately 45 km of the Kanuti River for nesting goshawks using a protocol developed by the US Forest Service (Woodbridge and Hargis 2006). We made one departure from this protocol by using a motorized skiff, rather than walking or using a terrestrial vehicle to move between survey stations. We found that the protocol with our modification was well suited for surveying goshawks and elicited four responses out of the 79 stations that we called along the river.

In 2012 we repeated the Kanuti River survey and conducted the same type of survey along the Jim and South Fork Koyukuk Rivers. In 2013 we repeated both surveys, but made the following additions to the routes: 1) we added more stations upstream of the old survey route on Kanuti River in order to expand our search for goshawks as far up the river as we could operate jetboats, and 2) we employed two different teams (hereafter Craig Team and Harwood Team), separated by a day, to survey the South Fork Koyukuk and Jim Rivers route in an attempt to measure detection error. Herein, we present the results of the 2013 surveys and make recommendations for further work.

**Study Areas**

We conducted the surveys along sections of three rivers on KNWR in 2013 (Figure 1). We surveyed the Kanuti River, including the additional new stations (distance ~55 km) upstream of the historical survey route, from 12–16 June. The most upstream station (66.22087° x -151.41623°) of the new portion of the route was located near "Arnica Hill" and continued downstream to the most downstream station (66.21388° x -152.09384°), a distance of just under 100 km for the total route. The South Fork Koyukuk and Jim Rivers survey route started at the Refuge's eastern boundary on the Jim River and continued downstream, first to the confluence with South Fork Koyukuk River, and then further downstream to that river's confluence with the main stem Koyukuk River, a distance of just under 90 km. A wildfire started near that survey route in June 2013, and ultimately burned both banks of the Jim River and a small portion of the South Fork Koyukuk River adjacent to the survey route. Because of the fire, we delayed departure for these surveys until 15 July, after the fire danger had quelled. The Craig and Harwood Teams conducted the two consecutive surveys of South Fork Koyukuk /Jim River until 19 and 20 July, respectively.

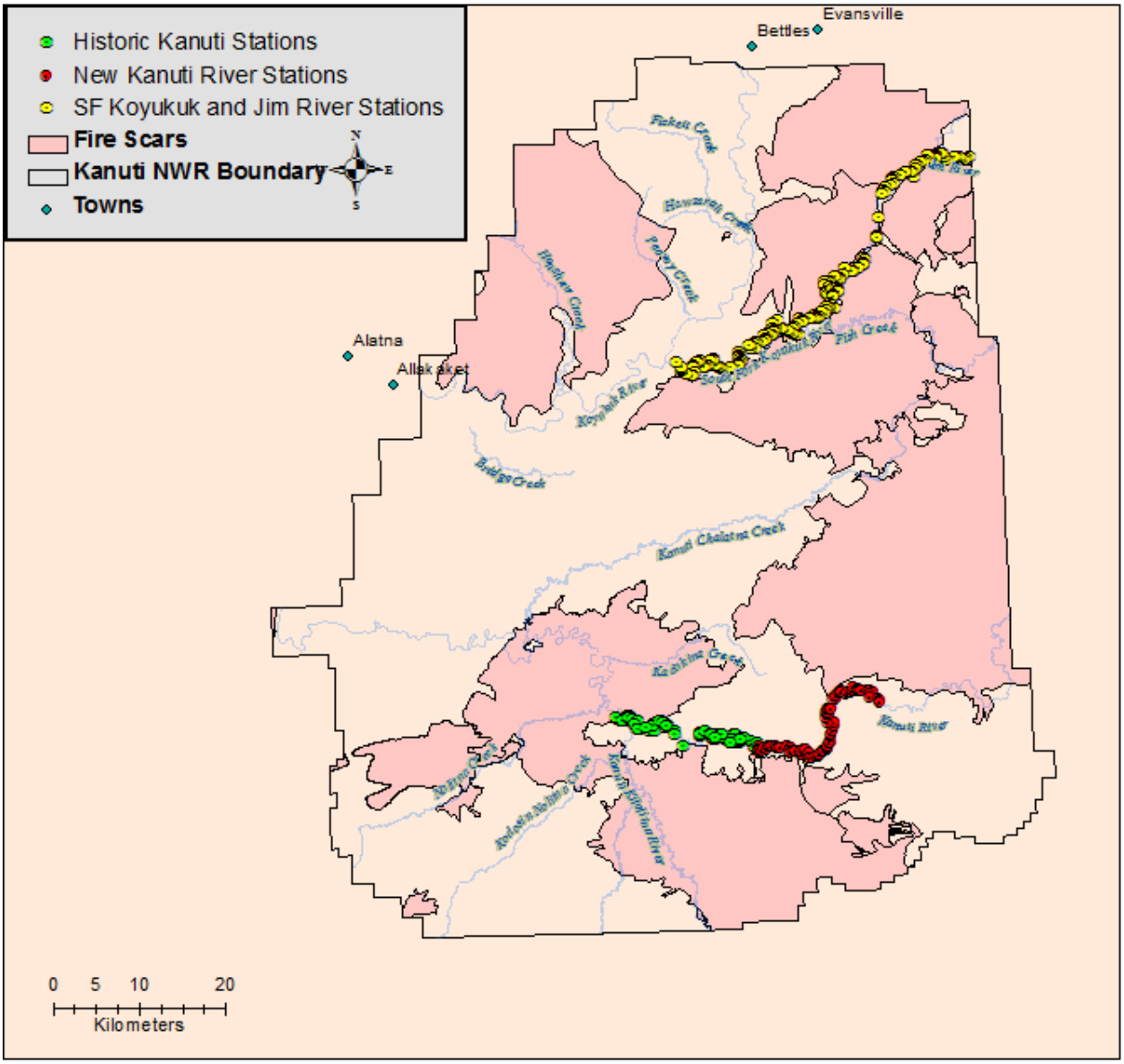



Figure 1. Locations of calling stations used in 2013 to survey nesting Northern Goshawks on portions of three rivers on Kanuti National Wildlife Refuge, Alaska.

**Methods**

The survey methods we used in 2013 on the Kanuti River route are described in Craig and Spindler (2011). Our survey methods on the South Fork Koyukuk/ Jim Rivers route were similar, except that we used non-motorized inflatable boats, floating at current speed (circa 3–4 km/hr.), to conduct that survey.

On both rivers, we selected calling stations based on three criteria. Stations were: 1) along the river, 2) within 200 m of "old growth" timber patches that were at least 10 ha in size, and 3) at least 200 m apart. On the upper Kanuti River (i.e. the new upstream survey stations) and the South Fork Koyukuk/ Jim River, the resulting number of stations was so great that we could not complete the survey in the time available for the project. Consequently, we randomly selected 10

stations within each of 10 segments containing an equal number of suitable calling stations for the entire South Fork Koyukuk/ Jim River route, and 8 stations within each of 10 segments for the supplementary, upper Kanuti River route. Although we had planned to call only at those stations, when we conducted the surveys we found that some stations were unusable and established new ones nearby. The reasons for these changes were:

- ambient noise was too great at some stations;
- the river had changed course in several places since the maps we used in GIS to select stations were drawn. Where this occurred, we moved the calling stations to appropriate habitat close to the original, projected calling station, and recorded a new GPS location for that station;
- we deleted 5 consecutive stations along one portion of the South Fork Koyukuk/ Jim River route because the river had changed course between 2012 and 2013.

In all, we surveyed 155 stations on the Kanuti River survey route. The Craig Team surveyed 155 stations on the South Fork Koyukuk/ Jim Rivers route and the Harwood Team surveyed 156 (Table 1). The GPS locations of stations called along Kanuti River are listed in Appendix 1 and those along the South Fork Koyukuk/ Jim Rivers in Appendix 2.

In addition to recording the responses of goshawks to the broadcast calls, we also noted the responses of other species to the calls. While there was some subjectivity in interpreting the behaviors of these animals, generally we ascribed a response to a bird or mammal if it appeared to move closer to us immediately following a calling sequence, and/or emitted an alarm call of its own after we played a call. Lastly, we recorded detections of other wildlife made during each calling sequence. These data are biased toward the larger, more visible species, but are consistent among surveys. Appendix 3 contains the scientific names and codes for non-target species discussed throughout this document.

**Table 1. Total number of stations called, river distance covered, and time spent during surveys for nesting Northern Goshawks in 2013 on portions of three rivers on Kanuti National Wildlife Refuge, Alaska.**

| Survey location | Team | Total Number of Stations Called | Total River Distance Covered | Total Time on the Survey (includes transit time) |
|---|---|---|---|---|
| Kanuti River | Craig and Dillard | 155 | 98.8 km | 37 hr. 22 min. |
| South Fork Koyukuk/ Jim River | Craig Team | 155 | 87.3 km | 47 hr. 36 min. |
| South Fork Koyukuk/ Jim River | Harwood Team | 156 | 87.3 km | 53 hr. 23 min. |

*Analysis*

We plotted the locations of all goshawk responses in GIS using ArcMap 10.1 (ESRI, Redmond, CA) and examined inter-nest distances to detect clustering and potential double-counting of

individuals. To evaluate the distribution of *responses* to calls at stations by non-target species, we divided the survey routes into 3 segments; each containing an equal number of stations (Figures 2 and 3). In contrast, to examine the distribution of *detections* of non-target species, we divided each route into 3 segments of equal length as we have done in past years so that inter-year comparisons can be made (Figures 4 and 5). The resulting segmentation for response and detection analysis were not identical, but were very similar. In both cases, we numbered the segments furthest upstream "1" and sequentially numbered the rest downstream from there. Appendix 4 contains the beginning and ending locations for each segment on both survey routes.

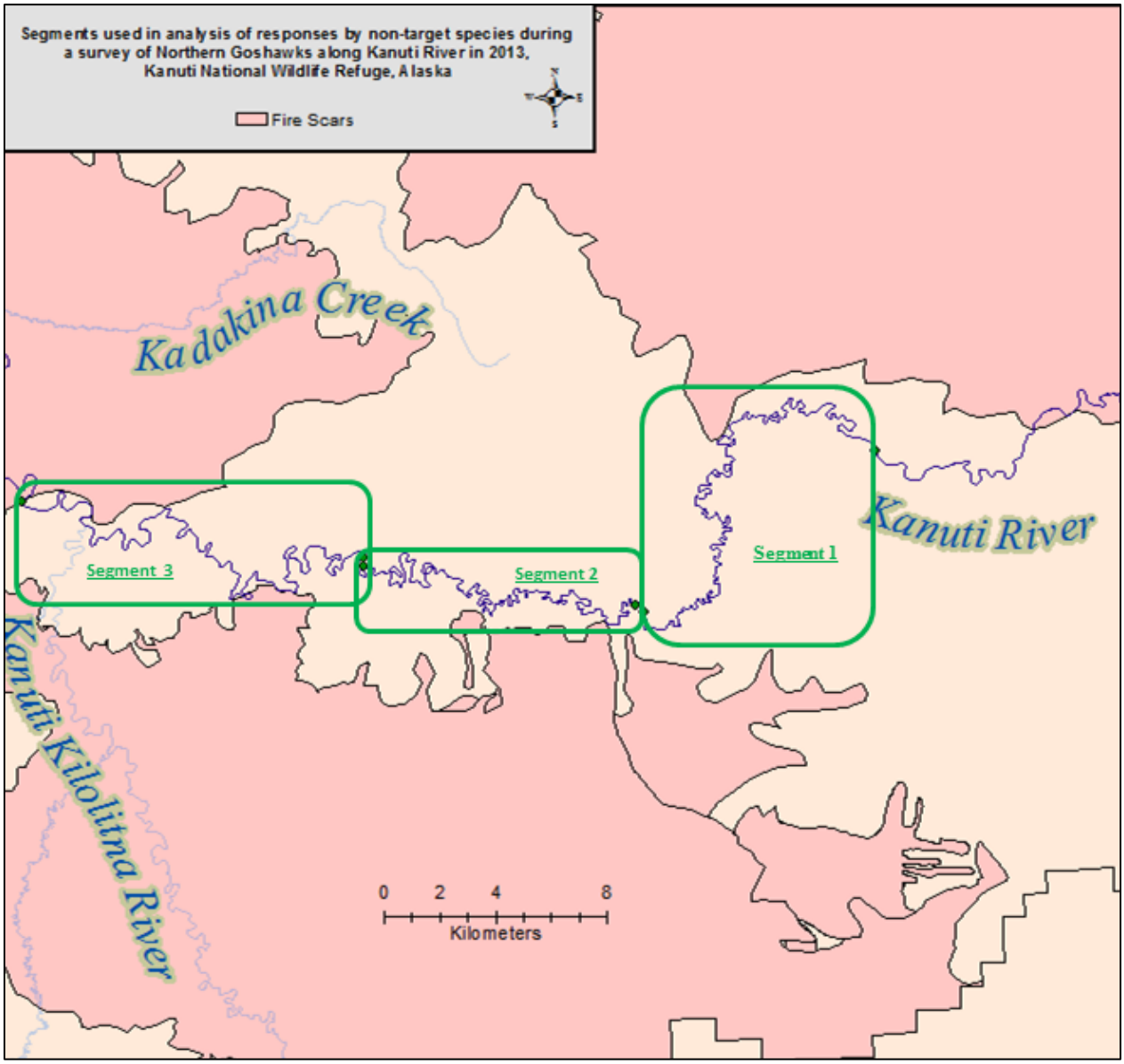



Figure 2. River segments used in analysis of responses by non-target species during a survey of Northern Goshawks along Kanuti River in 2013, Kanuti National Wildlife Refuge, Alaska.

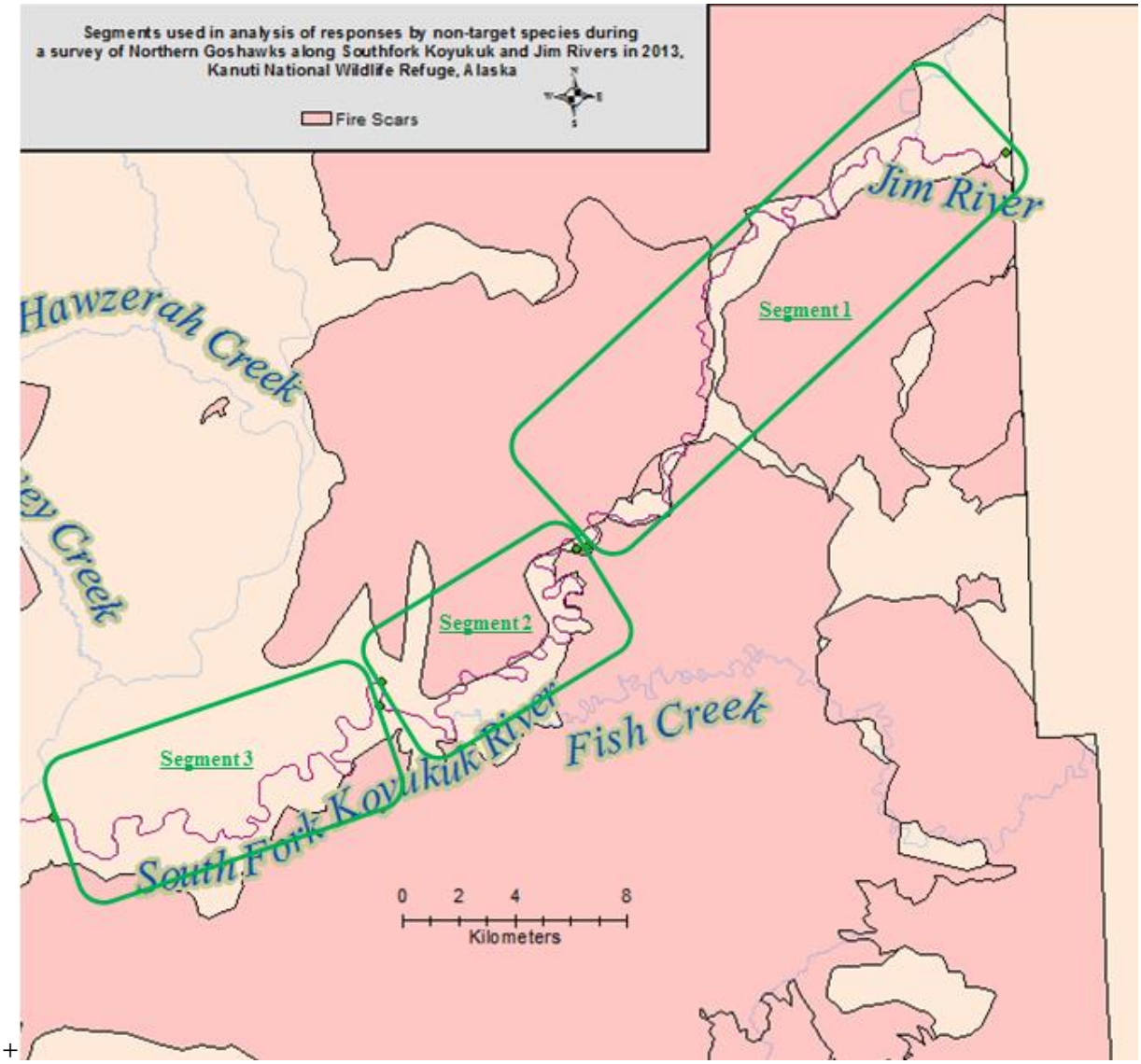



Figure 3. River segments (green rectangles) used in analysis of responses by non-target species during a survey of Northern Goshawks along South Fork Koyukuk and Jim Rivers in 2013, Kanuti National Wildlife Refuge, Alaska

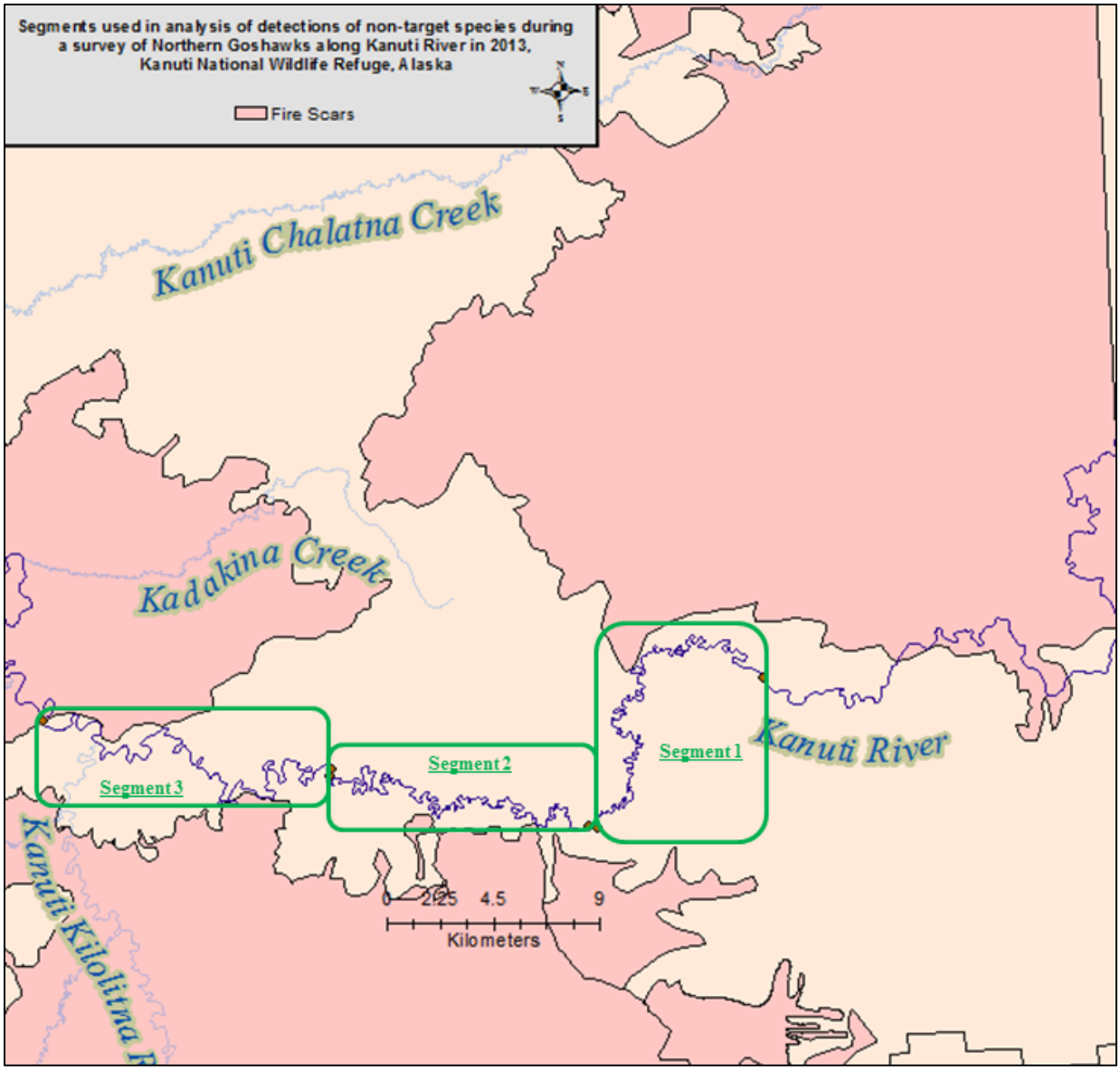



Figure 4. River segments (green rectangles) used in analysis of detections of non-target species during a survey of Northern Goshawks along Kanuti River in 2013, Kanuti National Wildlife Refuge, Alaska.

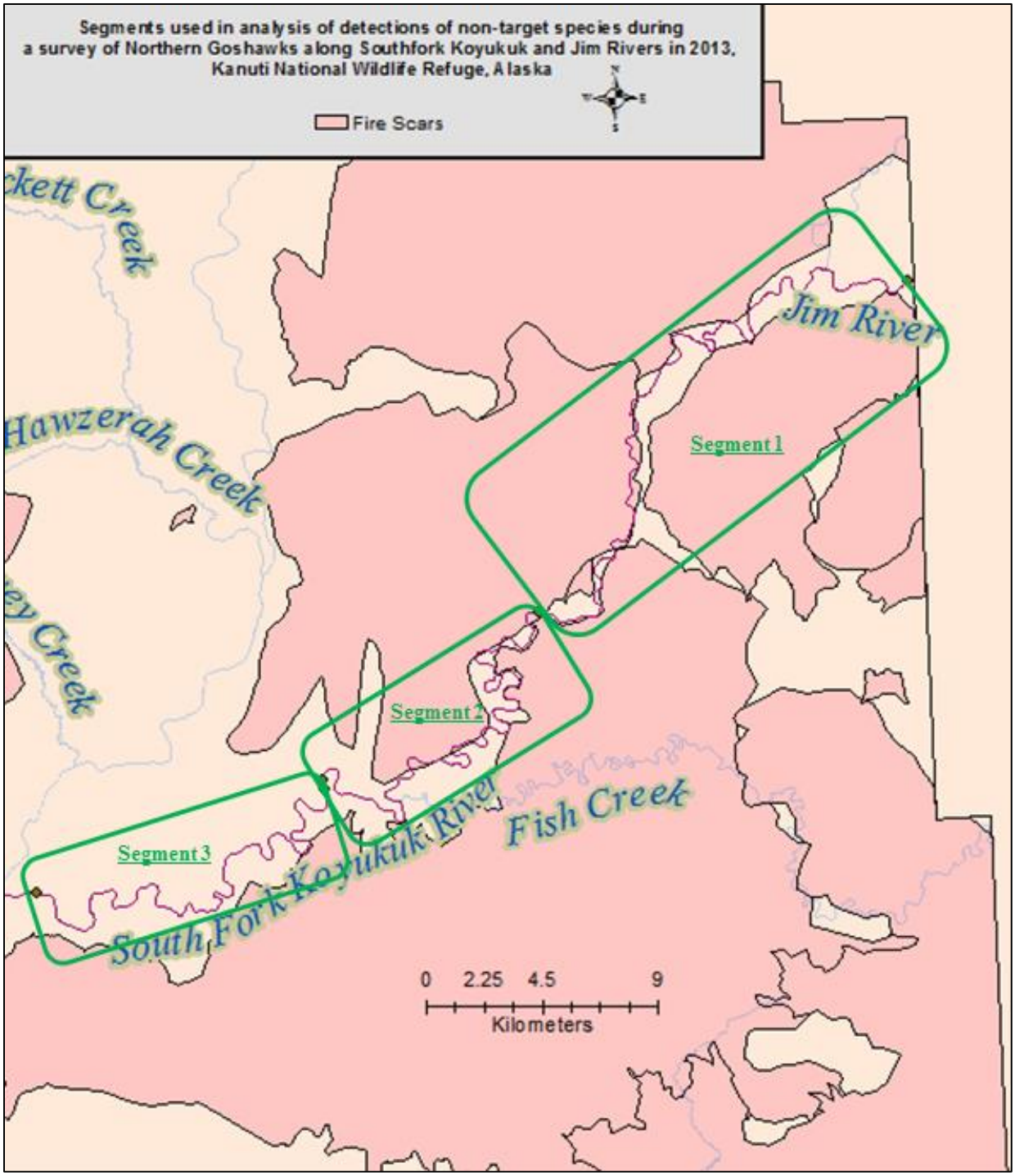


Figure 5. River segments (green rectangles) used in analysis of detections of non-target species during a survey of Northern Goshawks along South Fork Koyukuk and Jim Rivers in 2013, Kanuti National Wildlife Refuge, Alaska.

We used chi-square goodness of fit tests to analyze the response and detection results for non-target species (CHISQ.TEST, $\alpha = 0.05$; df = 2; Microsoft Office Excel 2010). The null hypothesis was that the number of detections and responses observed per segment were independent of the expected distribution. Expected values were determined by assuming that all

detected and responding individuals were evenly distributed in each segment. We performed chi-square analyses only for species in which the expected frequencies were at least 5 in each of the 3 river segments (after Zar 1998).

**Results**

*Northern Goshawks.* In 2013 we elicited responses from Northern Goshawks (NOGO) at nine calling stations during the Kanuti River survey and at three (Craig Team) and one (Harwood Team) during the South Fork Koyukuk/ Jim River surveys (Table 2). As has been found in past years, most of the NOGO responses in 2013 seemed to be spatially clustered (Figures 6 and 7), with more than half (7) within clusters that were $\leq$ 1 km wide. The maximum inter-year distance between responses within a cluster ranged from 3.6 - 5.1 km. Fewer NOGO responses were detected on the South Fork Koyukuk/ Jim River and they were also less "concentrated" than on the Kanuti River route. The one location where the Harwood Team detected goshawks in 2013 was proximal to where birds responded in 2012, and two of the stations where the Craig Team detected responses were relatively near stations where birds responded in 2012. The Craig Team also detected one isolated response in 2013.

**Table 2. Responses by Northern Goshawks to broadcast alarm or wail calls during a nesting survey on portions of three rivers on Kanuti National Wildlife Refuge, Alaska in 2013.**

| **Response*** | Survey location | Team | Station Number | Distance (km) to nearest station with a response in 2013 | Maximum distance (km) across apparent inter-year clusters (2011-2013) |
|---|---|---|---|---|---|
| **VGOS** | Kanuti River | Craig&Dillard | 481GR-10 | 2.3 | NA |
| **VGOS** | Kanuti River | Craig&Dillard | 458GR-9 | 2.3 | NA |
| **VGOS** | Kanuti River | Craig&Dillard | 41G | 1.0 | 5.1 |
| **VGOS** | Kanuti River | Craig&Dillard | 49G | 0.2 | |
| **VGOS** | Kanuti River | Craig&Dillard | 51G | 0.2 | |
| **VGOS** | Kanuti River | Craig&Dillard | 181G | 0.8 | 4.9 |
| **VGOS** | Kanuti River | Craig&Dillard | 188G | 0.8 | |
| **VGOS** | Kanuti River | Craig&Dillard | 198G | 0.9 | |
| **VGOS** | Kanuti River | Craig&Dillard | 203G | 0.9 | |
| **VGOS** | South Fork Koyukuk/Jim River | Craig | 201G | 3.4 | 5.1 |
| **VGOS** | South Fork Koyukuk/Jim River | Craig | 259GR-6 | 3.4 | |
| **VGOS** | South Fork Koyukuk/Jim River | Craig | 363G | 9.1 | Not in a cluster |
| **VGOS** | South Fork Koyukuk/Jim River | Harwood | 11GR-1 | 22.1 | 3.6 |

***VGOS- Vocal detection of a Northern Goshawk**

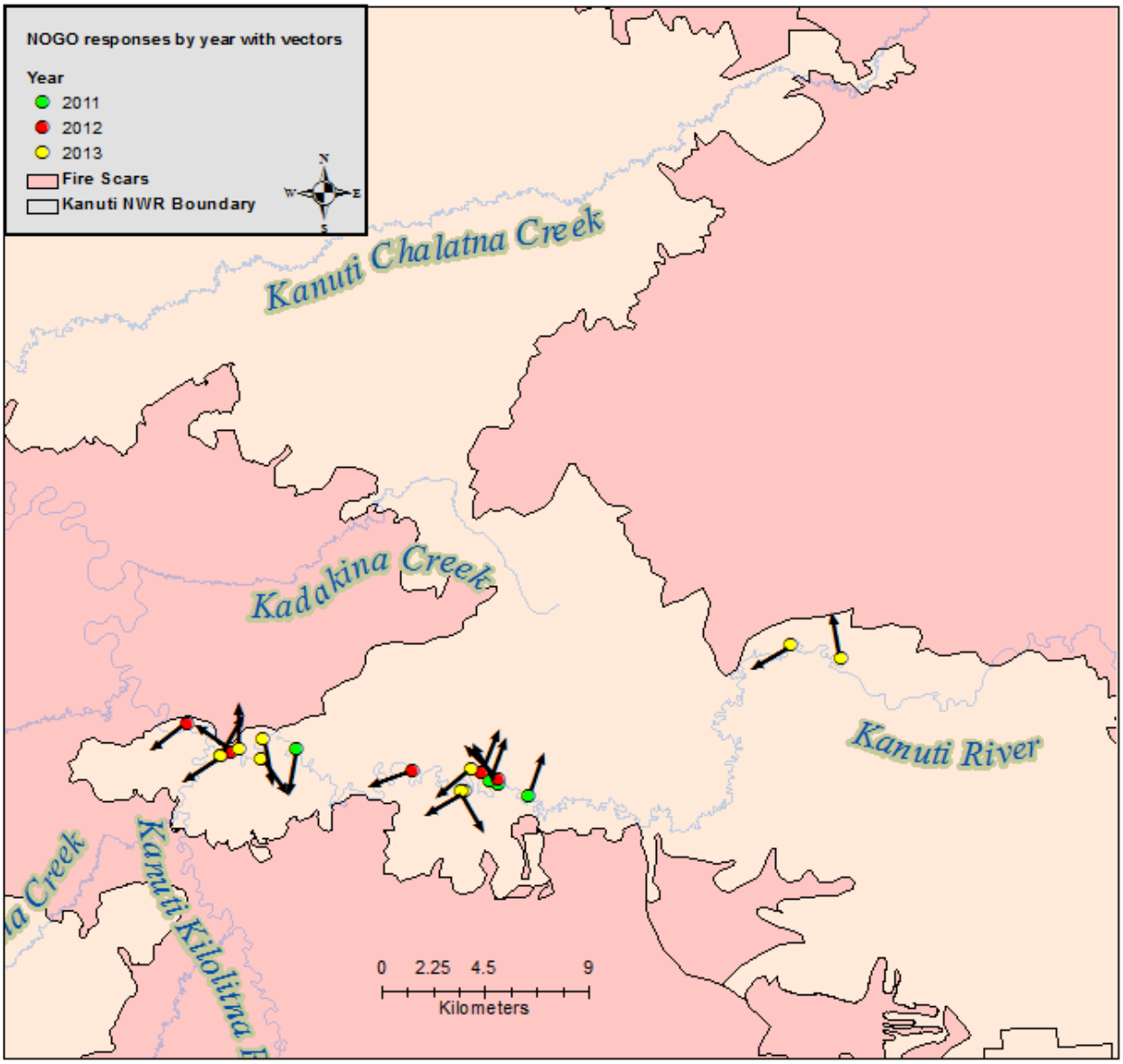



**Figure 6. Enlarged map showing locations where Northern Goshawks responded to broadcast goshawk calls 2011-2013 along Kanuti River on Kanuti National Wildlife Refuge, Alaska. Vector arrows indicate the direction from which responses emanated.**

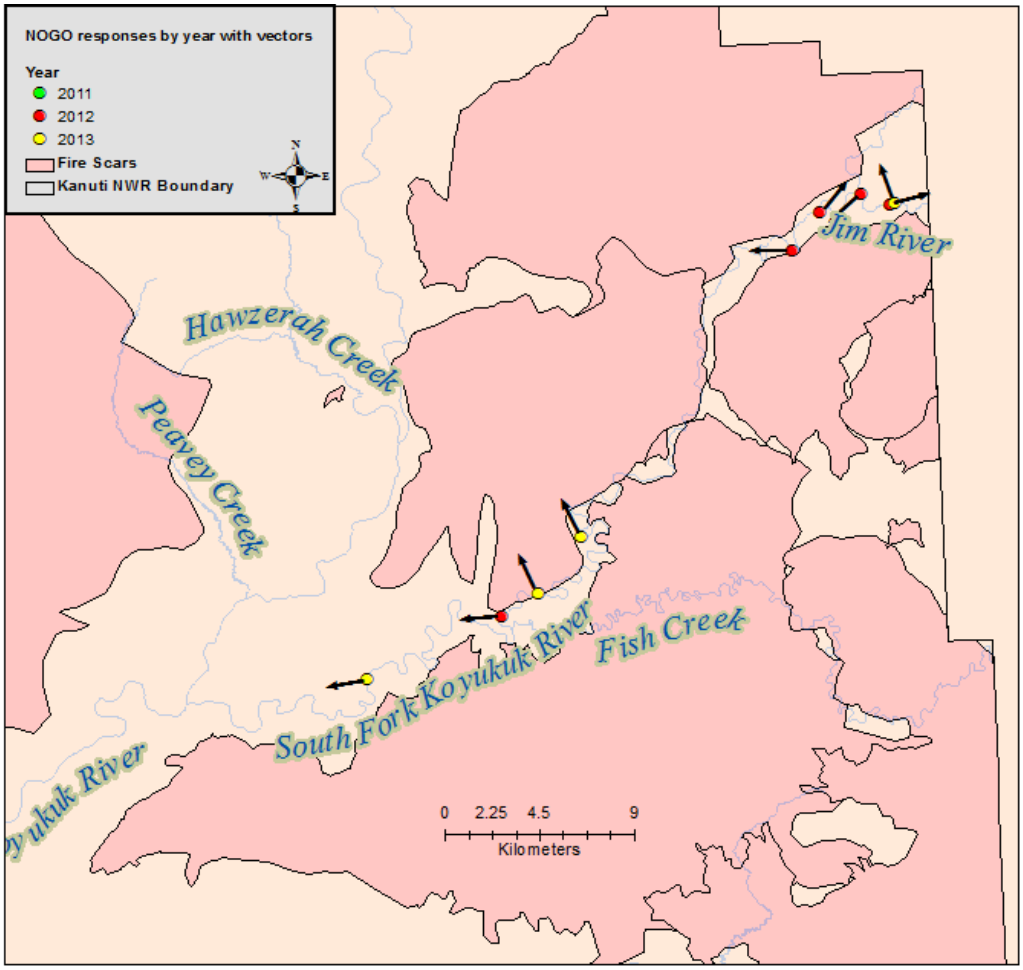



**Figure 7. Enlarged map showing locations where Northern Goshawks responded to broadcast goshawk calls 2012-2013 on South Fork Koyukuk and Jim Rivers on Kanuti National Wildlife Refuge, Alaska. Vector arrows indicate the direction from which responses emanated.**

*Responses by other species.*

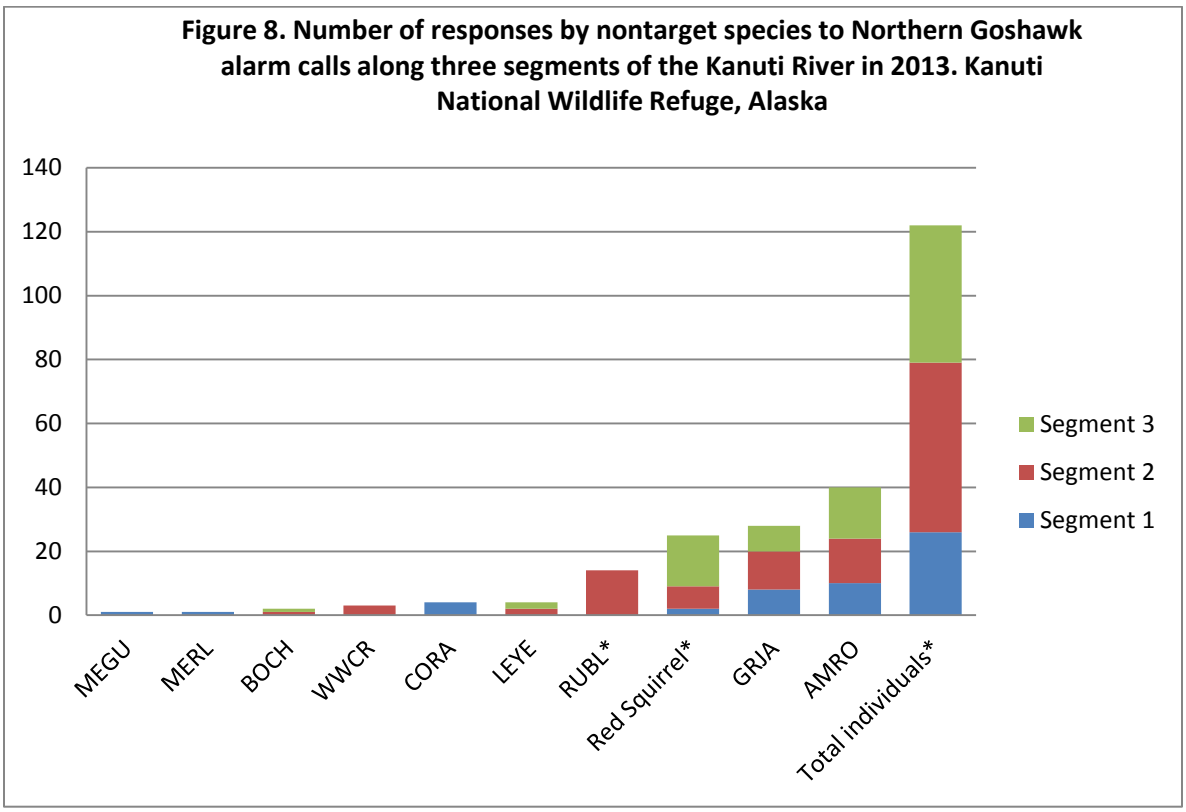
We elicited responses from species other than goshawks at 99 stations (64%) along the Kanuti River, but half of the responding species occurred at ≤ 3 stations. American Robins, Gray Jays and red squirrels responded most frequently (Figure 8). Our observations include:

- the same three species were the most common respondents in all survey years (2011–2013), although the order of magnitude varied;
- all of the Rusty Blackbirds that we detected were in segment 2, similar to our results from past surveys;
- significantly more red squirrels responded in segment 3, again as happened in the 2012 survey (Table 3);
- significantly fewer total individuals responded in segment 1

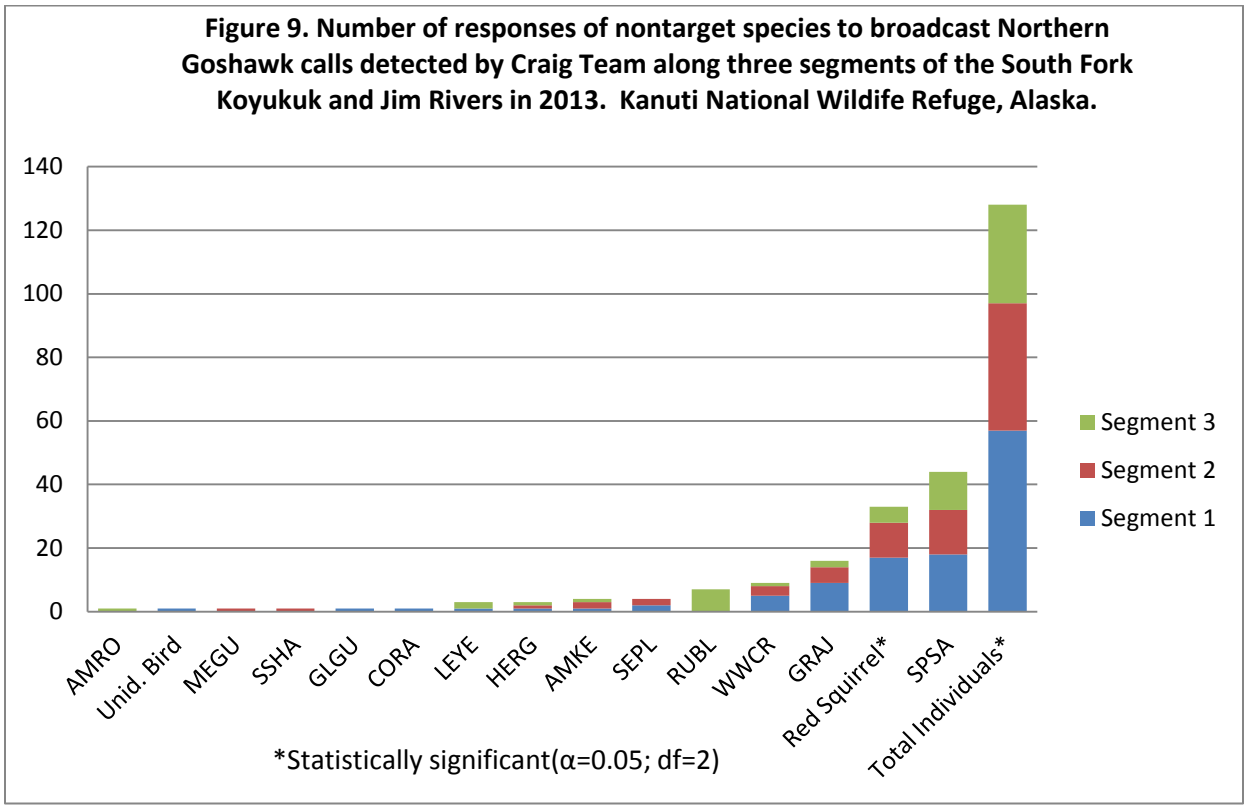
The Craig Team detected responses at 115 stations (74% of stations) from 15 different species along the South Fork Koyukuk/ Jim Rivers (Figure 9). Reminiscent of the 2012 survey, Spotted Sandpipers, red squirrels and Gray Jays responded most often at stations. The Harwood Team detected responses at 124 stations (80% of stations) along the South Fork Koyukuk/ Jim Rivers (Figure 10). Like the Craig Team, they found that the most numerous responses came from red squirrels, Gray Jays and Spotted Sandpipers, but the order of magnitude was somewhat different. Both the Craig and Harwood teams found that most species responded at $\leq$ 3 stations (73% and 68%, respectively). Our observations include:

- The same three species, Spotted Sandpipers, red squirrels and Gray Jays, were the most common respondents in all three of the 2012 and 2013 surveys, although the order of magnitude varied among surveys;
- Significantly more responding red squirrels and total individuals occurred in segment 1 during the Craig Team survey (Table 4) and more Spotted Sandpipers in segment 1 during the Harwood Team Survey (Table 5).
- Although the results were not significant, the Craig Team recorded more responding Spotted Sandpipers in segment 1 and the Harwood Team detected more red squirrels and total individuals in segment 1.

**Figure 8. Number of responses by nontarget species to Northern Goshawk alarm calls along three segments of the Kanuti River in 2013. Kanuti National Wildlife Refuge, Alaska**



| Table 3. Result of chi-square analysis of responses by non-target species to broadcast Northern Goshawk calls along three segments of the Kanuti River, 2013. Kanuti National Wildlife Refuge, Alaska (only significant results are listed). | | | |
|---|---|---|---|
| Survey route | **Species** | **P value (α = 0.05)** | **Comment** |
| **Kanuti River** | RUBL | 0.000067 | All in Segment 2 |
| **Kanuti River** | Red Squirrel | 0.002324 | More in Segment 3 |
| **Kanuti River** | Total No. responses | 0.010156 | Fewer in Segment 1 |




| Table 4. Result of chi-square analysis of responses by non-target species to broadcast Northern Goshawk calls detected by Craig Team along three segments of the South Fork Koyukuk and Jim Rivers in 2013. Kanuti National Wildlife Refuge, Alaska (only significant results are listed). | | | |
|---|---|---|---|
| Survey route | **Species** | **P value (α = 0.05)** | **Comment** |
| **South Fork Koyukuk and Jim Rivers** | Red Squirrel | 0.03790 | More in Segment 1 |
| **South Fork Koyukuk and Jim Rivers** | Total No. responses | 0.01455 | Fewer in Segment 3, more in Segment 1 |

**Figure 10. Number of responses of nontarget species to broadcast Northern Goshawk calls detected by Harwood Team along three segments of the South Fork Koyukuk and Jim Rivers in 2013. Kanuti National Wildife Refuge, Alaska.**

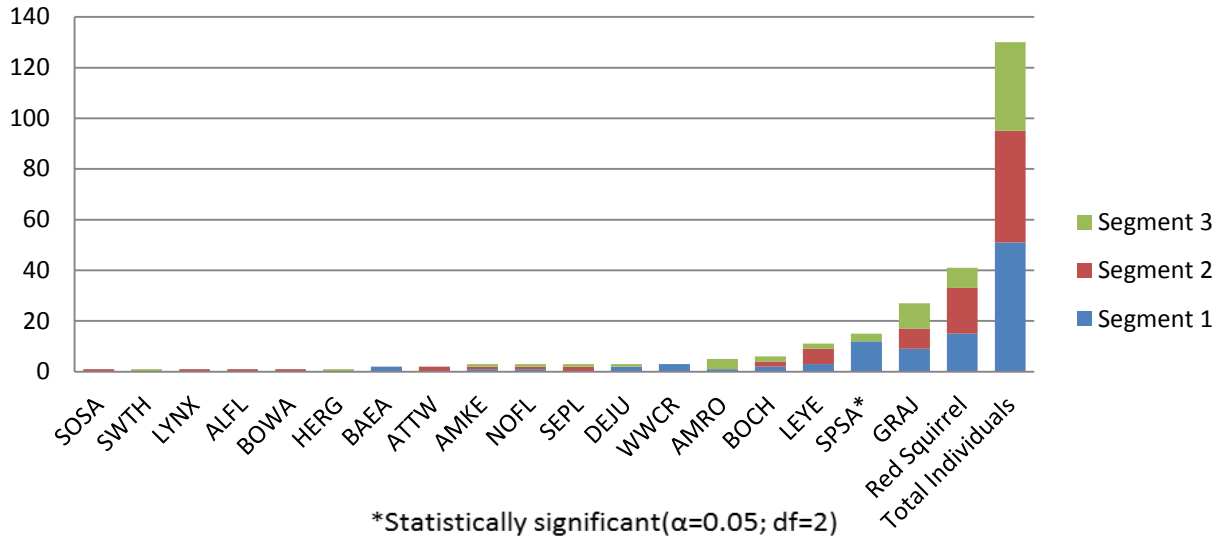



**Table 5. Result of chi-square analysis of responses by non-target species to broadcast Northern Goshawk calls detected by Harwood Team along three segments of the South Fork Koyukuk and Jim Rivers, 2013. Kanuti National Wildlife Refuge, Alaska (only significant results are listed) .**

| Survey route | **Species** | **P value (α=0.05)** | **Comment** |
|---|---|---|---|
| **South Fork Koyukuk and Jim Rivers** | SPSA | 0.00499 | None in Segment 2, more in Segment 1 |

*Detections of other species during surveys.*

We detected 30 different species (or other species-related features of note, like Bank Swallow [BANS] colonies) on the Kanuti River during the goshawk survey (Figure 11); Greater White-fronted Goose, American Wigeon and Olive-sided Flycatcher were the most frequently detected species. There were significantly more Greater White-fronted Geese in segment 2 than on the rest of the route (Table 6). Most (77%) of the species we detected occurred at $\leq$ 3 stations. The Craig Team recorded 35 species other than goshawks at 125 stations along the South Fork Koyukuk/ Jim River survey route. Spotted Sandpipers, Common Redpolls and Common Ravens were the most frequently encountered species. Most of the other animals they recorded (70%)

occurred at ≤ 3 stations (Figure 12). There were statistical differences in the number of animals detected, with Common Ravens spotted mostly in segment 2, but no Common Redpolls occurring in segment 1 (Table 7). They also saw more individuals in segment 3 than in 1. The Harwood Team detected more species than the Craig Team (46 vs. 35) and at more stations (149). Both teams detected more Spotted Sandpipers than any other species. However, in contrast to the Craig Team, the next most frequently detected species by the Harwood Team were White-winged Crossbills, Bohemian Waxwings and Semipalmated Plovers (Figure 13). Further, the Harwood team found statistically fewer Spotted Sandpipers and total individuals in segment 1 than elsewhere on the route (Table 8).

**Figure 11. Number of nontarget species detected during a Northern Goshawk survey along three segments of Kanuti River in 2013. Kanuti National Wildife Refuge, Alaska.**

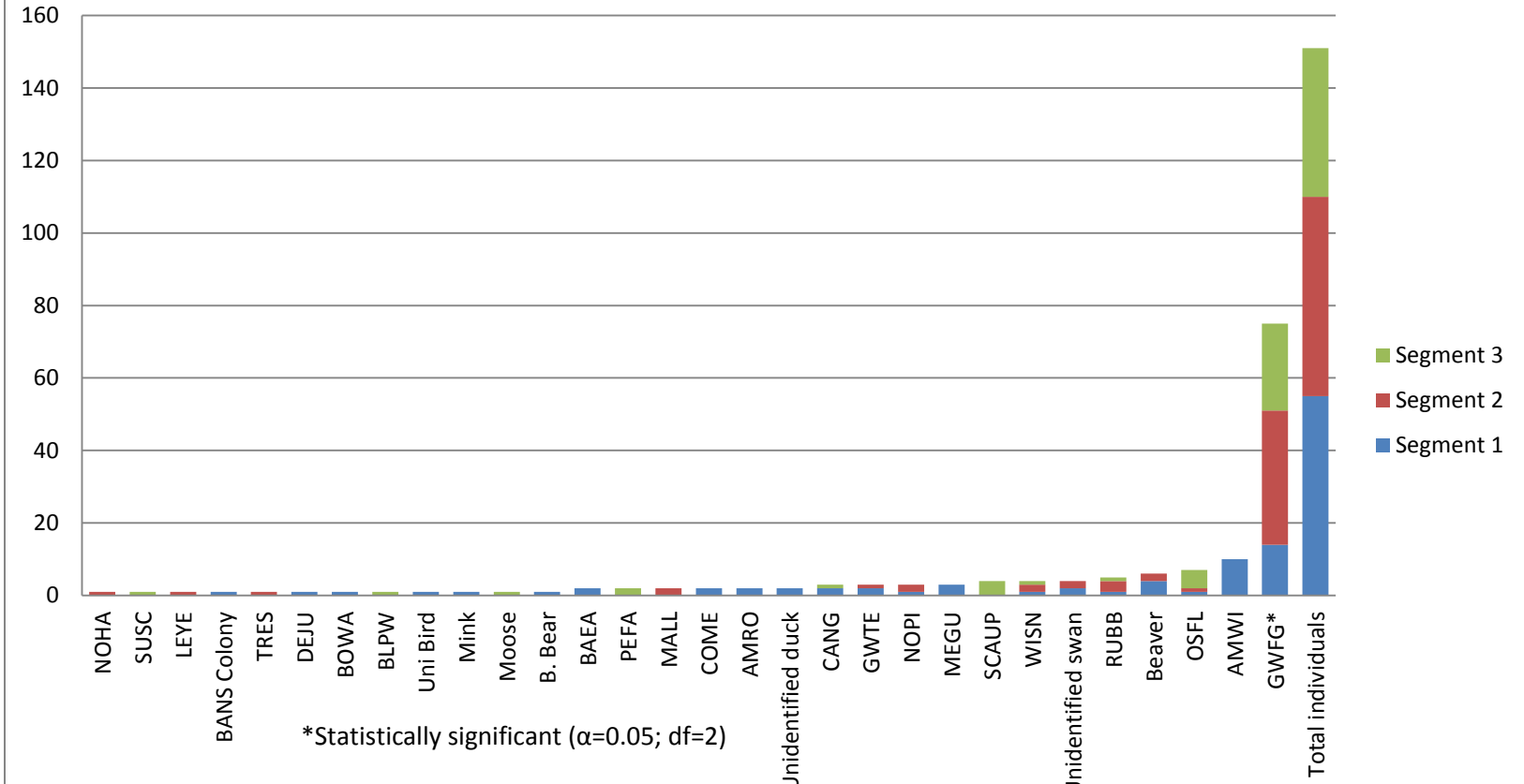


**Figure 12. Number of non-target species detected by Craig Team during a survey of Northern Goshawks along three segments of the South Fork Koyukuk and Jim Rivers in 2013. Kanuti National Wildlife Refuge, Alaska.**

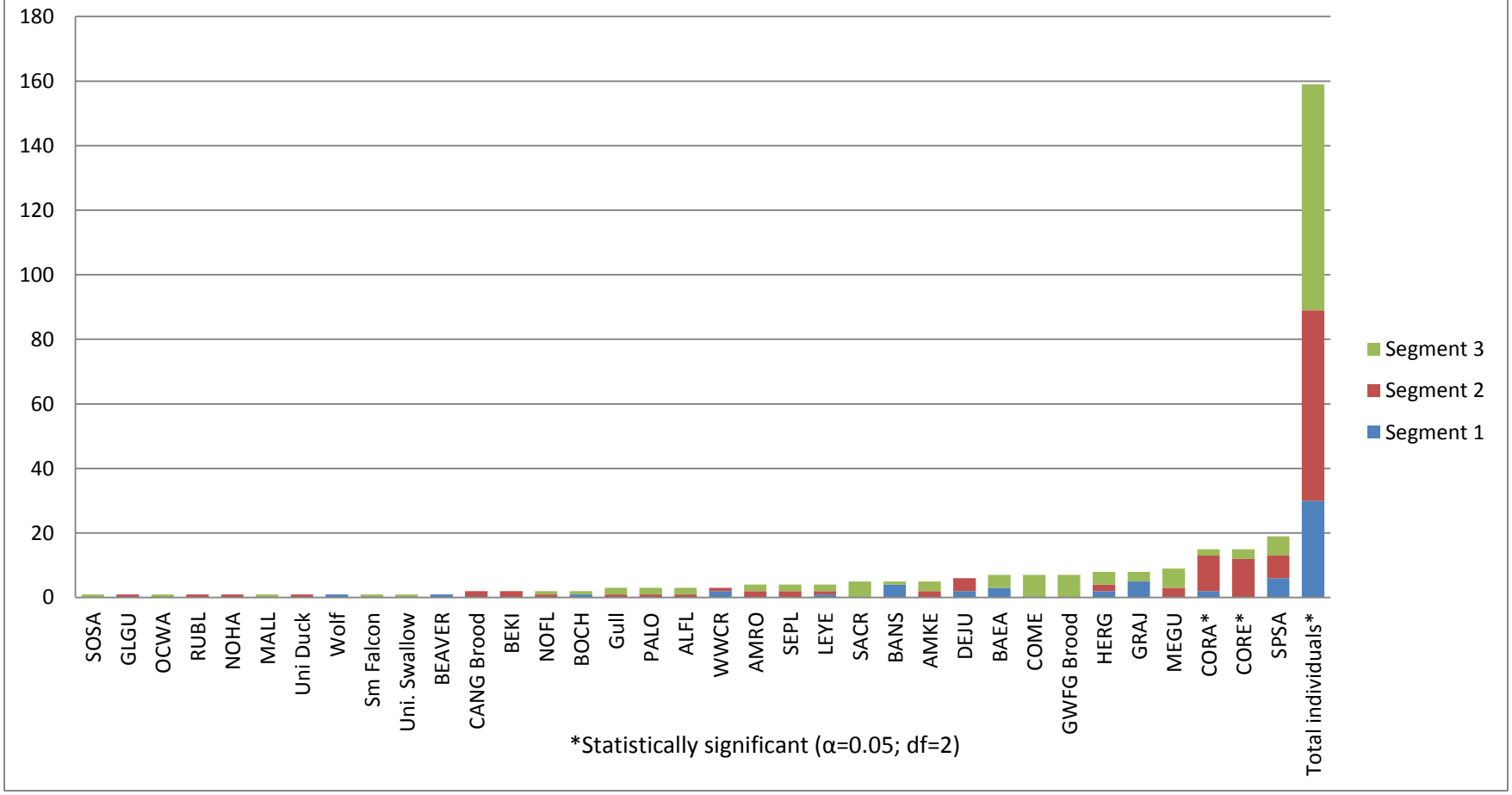


**Figure 13. Number of non-target species detected during a survey of Northern Goshawks detected by the Harwood Team along three segments of the South Fork Koyukuk and Jim Rivers in 2013. Kanuti National Wildlife Refuge, Alaska.**

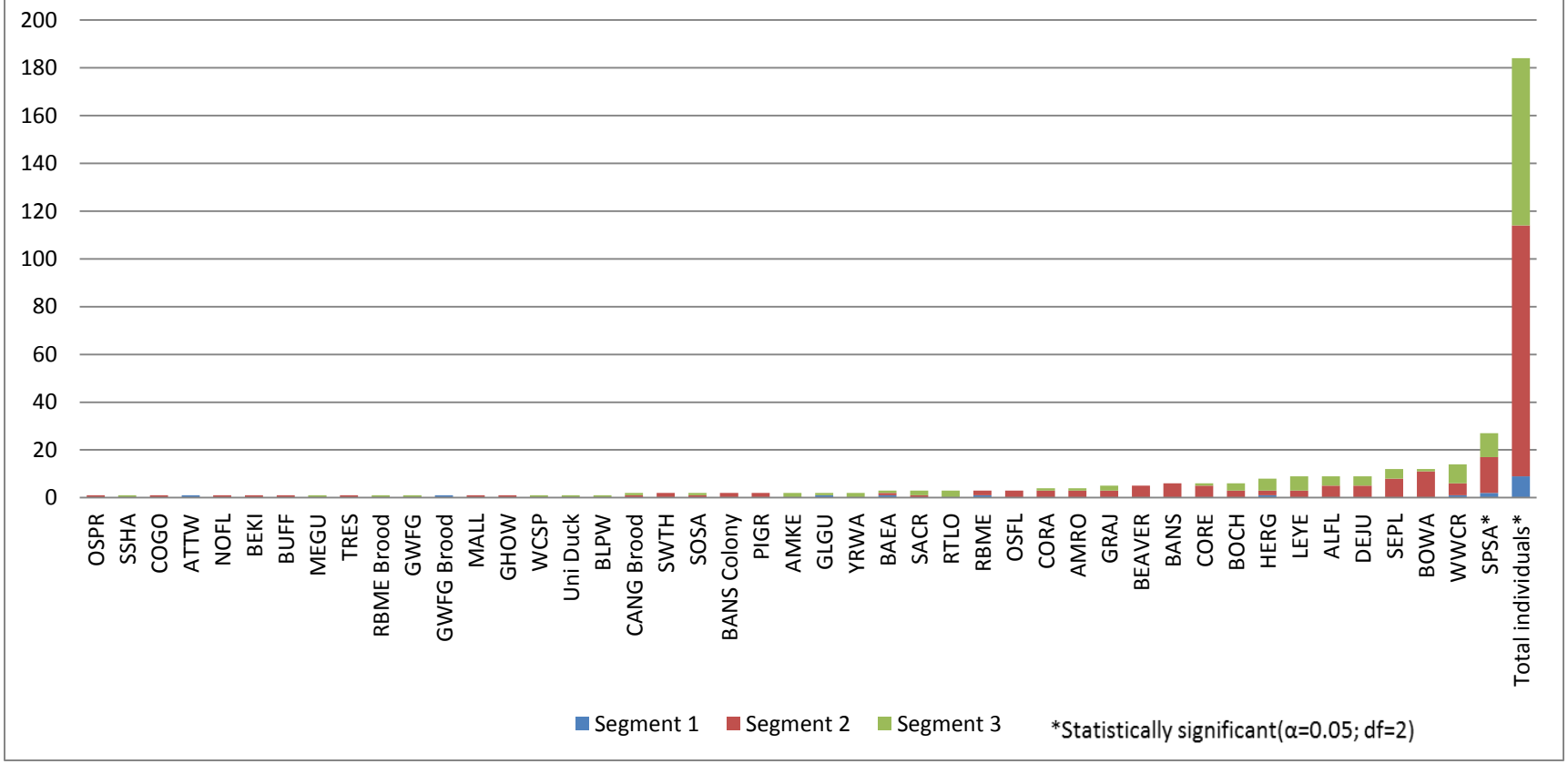


**Table 6. Results of chi-square analysis of detections of non-target species identified at Northern Goshawk calling stations along three segments of the Kanuti River in 2013. Kanuti National Wildlife Refuge, Alaska (only significant results are listed).**

| Survey route | **Species** | **P value (α = 0.05)** | **Comment** |
|---|---|---|---|
| **Kanuti River** | GWFG | 0.00489 | More in segment 2 |

**Table 7. Results of chi-square analysis of detections of non-target species detected by the Craig Team during a survey of Northern Goshawks along three segments of the South Fork Koyukuk and Jim Rivers in 2013. Kanuti National Wildlife Refuge, Alaska (only significant results are listed).**

| Survey route | **Species** | **P value (α = 0.05)** | **Comment** |
|---|---|---|---|
| **South Fork Koyukuk and Jim Rivers** | CORE | 0.00499 | None in Segment 1, more in Segment 2 |
| **South Fork Koyukuk and Jim Rivers** | CORA | 0.00452 | More in Segment 2 |
| **South Fork Koyukuk and Jim Rivers** | Total Individuals | 0.00003 | Fewer in Segment 1 |

**Table 8. Significant results of chi-square analysis of detections of non-target species identified by the Harwood Team during a survey of Northern Goshawks along 3 segments of the South Fork Koyukuk and Jim Rivers in 2013. Kanuti National Wildlife Refuge, Alaska (only significant results are listed).**

| Survey route | **Species** | **P value (α = 0.05)** | **Comment** |
|---|---|---|---|
| **South Fork Koyukuk and Jim Rivers** | SPSA | 0.00841 | Fewer in Segment 1, more in Segment 2 |
| **South Fork Koyukuk and Jim Rivers** | Total Individuals | 0.00000 | Fewer in Segment 1, more in Segment2 |

**Discussion**

Because the sample sizes of responding goshawks on the survey routes are quite small, caution must be exercised in interpreting the data. Nonetheless, Craig et al. (2012) noticed that there was a difference in response rates, if not the density of nesting goshawks, between the two survey areas with more responses occurring along the Kanuti River than the South Fork Koyukuk/ Jim River. Our results in 2013 were consistent with this observation. There are habitat differences along the two routes and that may somehow affected response rates. However, most of the responses from Northern Goshawks we elicited appeared to be clustered in just three groups in both of our survey areas (Figure 14). These clustered responses were within the mean nearest-neighbor distances for active goshawk nests reported in the literature (3.0 – 5.6 km; Reynolds

and Wright 1978, Squires and Reynolds 1997, Selås 2006) and we suspect that the responses within clusters were from birds in the same territories. Goshawks are known to re-use the same nest in different years but can also use alternate nests in the same territory, some up to 400 m apart (Reynolds and Wright 1978). Although the response rates were quite different on the two routes, it is possible that some of the inter-year responses within these clusters were by birds that showed fidelity to nesting territories. If true, this may indicate that the differences in response *rates* between the Kanuti and South Fork Koyukuk/ Jim Rivers routes were related to the phenological differences in behavioral responses of territorial birds during different stages of the nesting season.

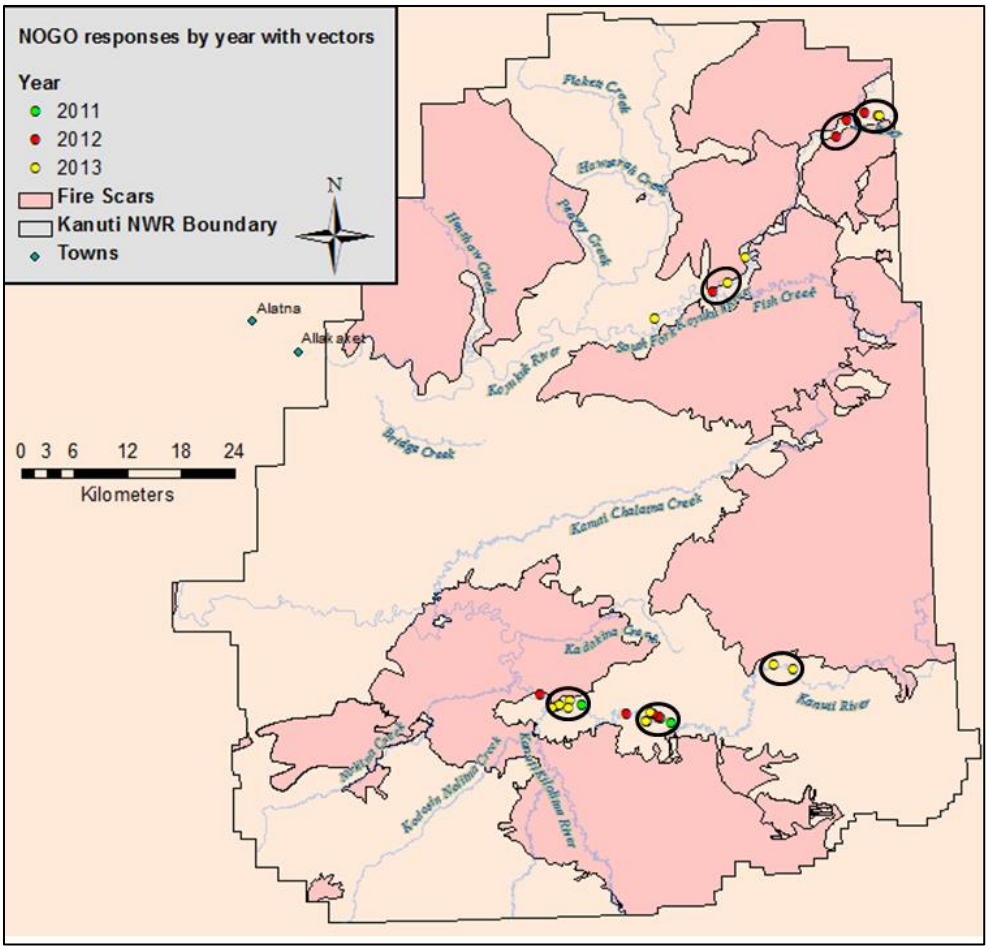



Figure 14. Clustered responses to broadcast alarm or wail calls by Northern Goshawks during nesting surveys on portions of three rivers on Kanuti National Wildlife Refuge, Alaska, 2011-2013. Black circles are approximately 5.6 km in diameter (after Reynolds and Wight 1978) and encompass all responses from within hypothesized territories.

The number of goshawk responses was so small on the South Fork Koyukuk/ Jim Rivers that we were unable to calculate detection rates differences in the results from the two survey teams in 2013. It is interesting that the one response the Harwood team experienced was very near a cluster of responses that was detected in 2012.

The same three non-target species responded most often to Northern Goshawk calls during both surveys in 2013 and during the surveys in past years. However, we detected no other statistical commonalities in responses between survey areas, among route segments, or survey years. This inconsistency probably reflects the complex interplay among ecosystem components and inter-annual weather and fire patterns.

We found interesting results when analyzing the detections made by the two different survey teams. First, the Harwood Team detected over 30% more total species than the Craig Team. Secondly, even though the two teams conducted the surveys no more than one day apart, the teams shared few common outcomes other than both detected Spotted Sandpipers most frequently. Factors that may have contributed to these results include:

- differences between the two teams, including total time spent surveying, aural/visual acuities, identification skills, taxonomic interest biases, etc.;
- differences in the time of day when a station that hosted an uncommon species was visited;
- differences in weather conditions when a station that hosted an uncommon species was visited;
- chance.

There were notable differences in the detections made by the Craig Team in the 2012 and 2013 surveys on the South Fork Koyukuk/ Jim Rivers. Common Ravens and Common Redpolls were among the top-4-most frequently detected species in both years. However, Bald Eagles, the most frequently spotted species in 2012, and Red-tailed "Harlan's" Hawks, the fifth most frequently spotted species in 2012, were infrequently spotted (Bald Eagles) or not spotted at all (Harlan's Hawks) in 2013. The near absence of these raptors in 2013 may have resulted from poor spring nesting conditions, as snow depths were still at winter levels well into May in 2013. Large raptors, like eagles, require a long nesting season to reproduce and severe weather conditions and/or wildfires are known to negatively affect their productivity (Swenson et al. 1986, Steenhof et al. 1997). Our results evince the significant influence of Arctic spring weather on raptor populations.

**Recommendations**

- We recommend that the South Fork Koyukuk/Jim River survey be repeated in 2014, but be run earlier in the summer, perhaps in mid-June. We do not know the timing of nesting for goshawks on the Refuge. By conducting the survey earlier in the summer, we may observe an increased response rate by territorial birds if there is a survey/timing mismatch with the nesting phenology of goshawks on the Refuge.
- We suggest that the Kanuti River survey route, including the new upstream segment, be resurveyed in June 2014.
- It appears that calling stations may be close enough together that we are repeatedly calling in birds from the same territory. Nonetheless, we suggest the same spacing be used in 2014 to determine if in fact the "clustering" effect occurs again. The results of multiple seasons of work will dictate changes in station placement for future surveys.

**Acknowledgements**
Erin Julianus of the Bureau of Land Management, Central Yukon Field Office, helped survey the South Fork Koyukuk/ Jim Rivers. Grace Sommer of USFWS drove the shuttle vehicle to drop us off on the Jim River. Scott Sample, NPS, picked up both crews at the mouth of the South Fork Koyukuk River and boated us upstream to Bettles, Alaska. Bradley Storm, USFWS, helped dry-out and store field gear at Bettles Field Station.

**Literature Citation**

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**Appendix 1. GPS locations (in degrees) of calling stations used on the Kanuti River survey route.**

| ID | Latitude | Longitude |
|---|---|---|
| **495GR-10** | 66.22087 | -151.41624 |
| **494GR-10** | 66.22253 | -151.41795 |
| **493GR-10** | 66.22367 | -151.42097 |
| **488GR-10** | 66.22703 | -151.44112 |
| **485GR-10** | 66.22941 | -151.44162 |
| **484GR-10** | 66.22825 | -151.43825 |
| **481GR-10** | 66.23080 | -151.43468 |
| **479GR-10** | 66.23249 | -151.44181 |
| **477GR-9** | 66.23256 | -151.44766 |
| **467GR-9** | 66.23404 | -151.46462 |
| **466GR-9** | 66.23359 | -151.46812 |
| **465GR-9** | 66.23366 | -151.47148 |
| **462GR-9** | 66.23618 | -151.47128 |
| **458GR-9** | 66.23659 | -151.48286 |
| **453GR-9** | 66.23480 | -151.48603 |
| **451GR-9** | 66.23263 | -151.49041 |
| **444GR-8** | 66.23200 | -151.49928 |
| **442GR-8** | 66.23134 | -151.50441 |
| **438GR-8** | 66.23341 | -151.51339 |
| **437GR-8** | 66.23282 | -151.51704 |
| **436GR-8** | 66.23432 | -151.51663 |
| **434GR-8** | 66.23320 | -151.52014 |
| **430GR-8** | 66.22912 | -151.53039 |
| **426GR-8** | 66.22644 | -151.53876 |
| **422GR-7** | 66.22582 | -151.53010 |
| **407GR-7** | 66.21478 | -151.54082 |
| **405GR-7** | 66.21618 | -151.54313 |
| **404GR-7** | 66.21584 | -151.54639 |
| **403GR-7** | 66.21485 | -151.54987 |
| **400GR-7** | 66.21160 | -151.55120 |
| **399GR-7** | 66.21178 | -151.55557 |
| **395GR-7** | 66.20964 | -151.54785 |
| **393GR-6** | 66.20777 | -151.55410 |
| **384GR-6** | 66.20136 | -151.55204 |
| **377GR-6** | 66.20077 | -151.53462 |

| | | |
|---|---|---|
| **374GR-6** | 66.19790 | -151.53551 |
| **373GR-6** | 66.19705 | -151.53367 |
| **368GR-6** | 66.19347 | -151.54181 |
| **361GR-6** | 66.18850 | -151.54460 |
| **359GR-6** | 66.18699 | -151.54470 |
| **353GR-5** | 66.18010 | -151.54835 |
| **352GR-5** | 66.17991 | -151.54431 |
| **346GR-5** | 66.17643 | -151.55443 |
| **345GR-5** | 66.17492 | -151.55307 |
| **344GR-5** | 66.17424 | -151.55459 |
| **339GR-5** | 66.17248 | -151.56294 |
| **338GR-5** | 66.17238 | -151.56618 |
| **333GR-5** | 66.16936 | -151.57891 |
| **331GR-4** | 66.16673 | -151.57754 |
| **328GR-4** | 66.16729 | -151.58578 |
| **326GR-4** | 66.16579 | -151.59332 |
| **324GR-4** | 66.16637 | -151.60173 |
| **320GR-4** | 66.17154 | -151.60447 |
| **316GR-4** | 66.17405 | -151.61156 |
| **313GR-4** | 66.17447 | -151.61707 |
| **310GR-4** | 66.17280 | -151.62235 |
| **305GR-3** | 66.16912 | -151.62498 |
| **299GR-3** | 66.17253 | -151.63857 |
| **298GR-3** | 66.17346 | -151.64213 |
| **296GR-3** | 66.17212 | -151.64846 |
| **293GR-3** | 66.17331 | -151.65604 |
| **288GR-3** | 66.17613 | -151.64759 |
| **287GR-3** | 66.17668 | -151.65170 |
| **285GR-3** | 66.17825 | -151.65874 |
| **276GR-2** | 66.17631 | -151.67735 |
| **275GR-2** | 66.17744 | -151.68038 |
| **274GR-2** | 66.17722 | -151.68428 |
| **270GR-2** | 66.17983 | -151.68924 |
| **267GR-2** | 66.17897 | -151.69813 |
| **265GR-2** | 66.17947 | -151.70239 |
| **262GR-2** | 66.17855 | -151.70599 |
| **258GR-2** | 66.17543 | -151.71134 |
| **254GR-1** | 66.17706 | -151.71852 |
| **251GR-1** | 66.17506 | -151.72288 |
| **250GR-1** | 66.17349 | -151.72497 |

| | | |
|---|---|---|
| **249GR-1** | 66.17245 | -151.72644 |
| **247GR-1** | 66.17440 | -151.73064 |
| **245GR-1** | 66.17580 | -151.73053 |
| **243GR-1** | 66.17673 | -151.72542 |
| **235GR-1** | 66.17964 | -151.73268 |
| **003G** | 66.18259 | -151.73714 |
| **004G** | 66.18134 | 151.74027 |
| **005G** | 66.18017 | -151.74346 |
| **006G** | 66.17876 | -151.74181 |
| **012G** | 66.18474 | -151.75275 |
| **016G** | 66.18714 | -151.76560 |
| **017G** | 66.18671 | -151.76892 |
| **018G** | 66.18841 | -151.76927 |
| **020G** | 66.18685 | -151.77617 |
| **021G** | 66.18815 | -151.77615 |
| **022G** | 66.18867 | -151.77199 |
| **024G** | 66.18970 | -151.77729 |
| **025G** | 66.18804 | -151.77847 |
| **026G** | 66.18647 | -151.77860 |
| **031G** | 66.18388 | -151.78228 |
| **035G** | 66.18772 | -151.78737 |
| **037G** | 66.19104 | -151.78437 |
| **040G** | 66.19298 | -151.79038 |
| **041G** | 66.19289 | -151.79436 |
| **045G** | 66.18647 | -151.79333 |
| **049G** | 66.18421 | -151.80070 |
| **051G** | 66.18427 | -151.80509 |
| **053G** | 66.18763 | -151.80396 |
| **057G** | 66.18851 | -151.79973 |
| **061G** | 66.18704 | -151.81480 |
| **069G** | 66.18957 | -151.82559 |
| **072G** | 66.19242 | -151.82440 |
| **076G** | 66.19291 | -151.83616 |
| **078G** | 66.19060 | -151.84261 |
| **079G** | 66.18885 | -151.84280 |
| **080G** | 66.18907 | -151.84609 |
| **081G** | 66.18922 | -151.84961 |
| **087G** | 66.19205 | -151.84636 |
| **088G** | 66.19271 | -151.84345 |
| **090G** | 66.19290 | -151.85068 |

| | | |
|---|---|---|
| **091G** | 66.19275 | -151.85495 |
| **092G** | 66.19440 | -151.85591 |
| **095G** | 66.19663 | -151.86579 |
| **105G** | 66.19281 | -151.88054 |
| **107G** | 66.19485 | -151.88142 |
| **108G** | 66.19609 | -151.87913 |
| **139G** | 66.18177 | -151.92439 |
| **154G** | 66.19451 | -151.94591 |
| **157G** | 66.19744 | -151.94620 |
| **165G** | 66.20309 | -151.96189 |
| **169G** | 66.20218 | -151.97139 |
| **170G** | 66.20328 | -151.96825 |
| **172G** | 66.20568 | -151.96632 |
| **173G** | 66.20628 | -151.97034 |
| **174G** | 66.20692 | -151.97433 |
| **177G** | 66.20983 | -151.97777 |
| **178G** | 66.20987 | -151.98163 |
| **181G** | 66.20732 | -151.99308 |
| **184G** | 66.20410 | -152.00244 |
| **188G** | 66.19964 | -151.99617 |
| **193G** | 66.19835 | -152.01170 |
| **198G** | 66.20353 | -152.01667 |
| **199G** | 66.20338 | -152.02069 |
| **200G** | 66.20230 | -152.02422 |
| **203G** | 66.20089 | -152.03516 |
| **206G** | 66.20109 | -152.04076 |
| **208G** | 66.20415 | -152.03944 |
| **209G** | 66.20527 | -152.04282 |
| **210G** | 66.20603 | -152.04656 |
| **214G** | 66.20992 | -152.03948 |
| **218G** | 66.21249 | -152.05133 |
| **219G** | 66.21122 | -152.05446 |
| **220G** | 66.21061 | -152.05847 |
| **222G** | 66.21306 | -152.06292 |
| **223G** | 66.21472 | -152.06132 |
| **225G** | 66.21560 | -152.06604 |
| **226G** | 66.21384 | -152.06662 |
| **227G** | 66.21217 | -152.06763 |
| **229G** | 66.21065 | -152.07551 |
| **230G** | 66.21058 | -152.07993 |

| | | |
|---|---|---|
| **231G** | 66.21102 | -152.08409 |
| **232G** | 66.21167 | -152.08820 |
| **233G** | 66.21230 | -152.09230 |
| **234G** | 66.21388 | -152.09384 |

**Appendix 2. GPS locations (in degrees) of calling stations used on the South Fork Koyukuk/ Jim River survey route.**

| Id | Latitude | Longitude |
|---|---|---|
| **001GR-1** | 66.78379 | -151.12826 |
| **003GR-1** | 66.78211 | -151.13535 |
| **005GR-1** | 66.78012 | -151.14270 |
| **007GR-1** | 66.78220 | -151.14835 |
| **009GR-1** | 66.78477 | -151.15317 |
| **011GR-1** | 66.78471 | -151.16171 |
| **012GR-1** | 66.78424 | -151.16592 |
| **017GR-1** | 66.78169 | -151.18593 |
| **018GR-1** | 66.78178 | -151.19025 |
| **021GR-1** | 66.78583 | -151.19526 |
| **023GR-1** | 66.78877 | -151.19746 |
| **024GR-1** | 66.78958 | -151.20116 |
| **028G** | 66.78730 | -151.21377 |
| **029GR-1** | 66.78558 | -151.21473 |
| **030GR-1** | 66.78406 | -151.21707 |
| **034GR-2** | 66.78376 | -151.23166 |
| **035GR-2** | 66.78555 | -151.23187 |
| **037GR-2** | 66.78693 | -151.23849 |
| **040GR-2** | 66.78206 | -151.24257 |
| **041GR-2** | 66.78128 | -151.24628 |
| **044GR-2** | 66.78013 | -151.25725 |
| **046GR-2** | 66.77803 | -151.26435 |
| **047GR-2** | 66.77697 | -151.26798 |
| **049GR-2** | 66.77374 | -151.27123 |
| **055GR-2** | 66.76590 | -151.27324 |
| **058GR-2** | 66.77030 | -151.27996 |
| **059GR-2** | 66.77139 | -151.28338 |
| **062GR-2** | 66.77178 | -151.29539 |
| **063GR-2** | 66.77048 | -151.29852 |
| **067GR-2** | 66.76779 | -151.31127 |
| **076GR-3** | 66.76650 | -151.32635 |
| **077GR-3** | 66.76532 | -151.33055 |
| **084GR-3** | 66.76249 | -151.33130 |
| **085GR-3** | 66.75971 | -151.33054 |
| **086GR-3** | 66.75794 | -151.33632 |
| **090GR-3** | 66.75644 | -151.35287 |
| **092GR-3** | 66.75323 | -151.35425 |

| | | |
|---|---|---|
| **093GR-3** | 66.75103 | -151.35109 |
| **094GR-3** | 66.74882 | -151.35971 |
| **114** | 66.72426 | -151.37294 |
| **126GR-3** | 66.70623 | -151.37857 |
| **127GR-3** | 66.70451 | -151.37907 |
| **146G** | 66.68335 | -151.41359 |
| **147GR-3** | 66.68095 | -151.41040 |
| **149GR-3** | 66.67870 | -151.41801 |
| **151GR-3** | 66.67622 | -151.41794 |
| **156GR-4** | 66.67233 | -151.42845 |
| **160G** | 66.66997 | -151.44391 |
| **161GR-4** | 66.67030 | -151.44931 |
| **163G** | 66.67331 | -151.46376 |
| **164GR-4** | 66.67332 | -151.46376 |
| **173G** | 66.66743 | -151.46992 |
| **175GR-4** | 66.66296 | -151.47701 |
| **176GR-4** | 66.66238 | -151.47802 |
| **177GR-4** | 66.66208 | -151.48630 |
| **179G** | 66.66515 | -151.49088 |
| **184GR-4** | 66.66064 | -151.50681 |
| **185GR-4** | 66.66081 | -151.51132 |
| **186GR-4** | 66.66082 | -151.51712 |
| **190GR-4** | 66.65727 | -151.52021 |
| **191GR-4** | 66.65662 | -151.51819 |
| **193GR-4** | 66.65554 | -151.50767 |
| **194GR-4** | 66.65421 | -151.50514 |
| **196GR-4** | 66.65034 | -151.51204 |
| **197GR-5** | 66.64944 | -151.51422 |
| **198GR-5** | 66.64939 | -151.51483 |
| **199GR-5** | 66.64809 | -151.51640 |
| **201G** | 66.64692 | -151.51262 |
| **203G** | 66.64872 | -151.49991 |
| **204GR-5** | 66.65121 | -151.50049 |
| **205GR-5** | 66.65289 | -151.49796 |
| **208GR-5** | 66.65259 | -151.48683 |
| **209GR-5** | 66.65054 | -151.48476 |
| **210GR-5** | 66.64882 | -151.48369 |
| **214GR-5** | 66.64576 | -151.49948 |
| **215GR-5** | 66.64460 | -151.49867 |
| **226GR-5** | 66.63822 | -151.50824 |
| **227GR-5** | 66.63639 | -151.50414 |

| | | |
|---|---|---|
| **230GR-5** | 66.63263 | -151.49577 |
| **232GR-5** | 66.63285 | -151.50688 |
| **233GR-5** | 66.63442 | -151.51308 |
| **234GR-5** | 66.63425 | -151.51463 |
| **235GR-5** | 66.63395 | -151.51678 |
| **238GR-6** | 66.63021 | -151.51862 |
| **240GR-6** | 66.62708 | -151.52003 |
| **242GR-6** | 66.62933 | -151.52849 |
| **249GR-6** | 66.62508 | -151.54636 |
| **250GR-6** | 66.62412 | -151.54253 |
| **251GR-6** | 66.62460 | -151.53696 |
| **255GR-6** | 66.62135 | -151.53900 |
| **256GR-6** | 66.62226 | -151.54378 |
| **257GR-6** | 66.62209 | -151.54869 |
| **258GR-6** | 66.62296 | -151.55618 |
| **259GR-6** | 66.62320 | -151.56082 |
| **262GR-6** | 66.62218 | -151.59027 |
| **269GR-6** | 66.62073 | -151.58177 |
| **270GR-6** | 66.61842 | -151.57915 |
| **272GR-6** | 66.61719 | -151.59125 |
| **275GR-6** | 66.61390 | -151.60109 |
| **277GR-6** | 66.61230 | -151.60526 |
| **283GR-7** | 66.60564 | -151.58989 |
| **287GR-7** | 66.60477 | -151.59723 |
| **289GR-7** | 66.60678 | -151.60500 |
| **290GR-7** | 66.60689 | -151.60755 |
| **292GR-7** | 66.60993 | -151.61664 |
| **293GR-7** | 66.61098 | -151.62119 |
| **296GR-7** | 66.61234 | -151.63411 |
| **297GR-7** | 66.61268 | -151.63857 |
| **300GR-7** | 66.61398 | -151.64897 |
| **305GR-7** | 66.62155 | -151.64700 |
| **309GR-7** | 66.61789 | -151.65927 |
| **311GR-7** | 66.61417 | -151.65697 |
| **312GR-7** | 66.61214 | -151.65604 |
| **313GR-7** | 66.61032 | -151.65688 |
| **315GR-7** | 66.60708 | -151.66068 |
| **316GR-7** | 66.6069 | -151.66489 |
| **318GR-7** | 66.60828 | -151.67340 |
| **324GR-8** | 66.60708 | -151.68129 |
| **326GR-8** | 66.60336 | -151.67693 |

| | | |
|---|---|---|
| **327GR-8** | 66.60127 | -151.67807 |
| **329GR-8** | 66.59996 | -151.68546 |
| **343GR-8** | 66.59872 | -151.69917 |
| **344GR-8** | 66.59972 | -151.70282 |
| **346GR-8** | 66.59782 | -151.70903 |
| **349GR-8** | 66.59293 | -151.70622 |
| **352GR-8** | 66.59246 | -151.71645 |
| **353GR-8** | 66.54426 | -151. 1785 |
| **354GR-8** | 66.596 | -151.71892 |
| **355GR-8** | 66.59616 | -151.72089 |
| **363G** | 66.58921 | -151.74763 |
| **364GR-9** | 66.58729 | -151.74818 |
| **366GR-9** | 66.58436 | -151.74869 |
| **367GR-9** | 66.58332 | -151.74446 |
| **368GR-9** | 66.58165 | -151.74254 |
| **370GR-9** | 66.57878 | -151.74384 |
| **371GR-9** | 66.57849 | -151.75063 |
| **376GR-9** | 66.57676 | -151.75119 |
| **380GR-9** | 66.5732 | -151.76685 |
| **381GR-9** | 66.57381 | -151.77271 |
| **389GR-9** | 66.57374 | -151.79320 |
| **390GR-9** | 66.5751 | -151.79951 |
| **391GR-9** | 66.57533 | -151.80397 |
| **392GR-9** | 66.57617 | -151.80804 |
| **393GR-9** | 66.57719 | -151.81013 |
| **398GR-9** | 66.58360 | -151.81573 |
| **399GR-9** | 66.58272 | -151.81615 |
| **400GR-9** | 66.5815 | -151.82201 |
| **403GR-10** | 66.5775 | -151.82883 |
| **404GR-10** | 66.57638 | -151.83270 |
| **405GR-10** | 66.57616 | -151.83562 |
| **406GR-10** | 66.57615 | -151.84343 |
| **411GR-10** | 66.58253 | -151.84798 |
| **413GR-10** | 66.5815 | -151.85556 |
| **414GR-10** | 66.58110 | -151.86079 |
| **417GR-10** | 66.57749 | -151.86734 |
| **418G** | 66.57551 | -151.86609 |
| **421GR-10** | 66.57139 | -151.86508 |
| **423GR-10** | 66.56775 | -151.86858 |
| **424GR-10** | 66.56767 | -151.87523 |
| **427GR-10** | 66.56992 | -151.88576 |

| | | |
|---|---|---|
| **430GR-10** | 66.57267 | -151.89687 |
| **431GR-10** | 66.57439 | -151.89786 |
| **432GR-10** | 66.57650 | -151.89746 |
| **437GR-10** | 66.58167 | -151.91254 |

**Appendix 3. Scientific names and species codes used in this report**

| Common Name | 4-Letter Code | Scientific Name |
|---|---|---|
| *Birds* | | |
| Alder Flycatcher | ALFL | *Empidonax alnorum* |
| American Kestrel | AMKE | *Falco sparverius* |
| American Robin | AMRO | *Turdus migratorius* |
| American Three-toed Woodpecker | ATTW | *Picoides dorsalis* |
| American Wigeon | AMWI | *Anas americana* |
| Bald Eagle | BAEA | *Haliaeetus leucocephalus* |
| Bank Swallow | BANS | *Riparia riparia* |
| Belted Kingfisher | BEKI | *Megaceryle alcyon* |
| Blackpoll Warbler | BLPW | *Setophaga striata* |
| Bohemian Waxwing | BOWA | *Bombycilla garrulous* |
| Boreal Chickadee | BOCH | *Poecile hudsonicus* |
| Bufflehead | BUFF | *Bucephala albeola* |
| Canada Goose | CANG | *Branta canadensis* |
| Common Goldeneye | COGO | *Bucephala clangula* |
| Common Merganser | COME | *Mergus merganser* |
| Common Raven | CORA | *Corvus corax* |
| Wilson Snipe | WISN | *Gallinago delicata* |
| Dark-eyed Junco | DEJU | *Junco hyemalis* |
| Glaucous-winged Gull | GLGU | *Larus glaucescens* |
| Gray Jay | GRAJ | *Perisoreus canadensis* |
| Great Gray Owl | GGOW | *Strix nebulosa* |
| Great Horned Owl | GHOW | *Bubo virginianus* |

| | | |
|---|---|---|
| Greater White-fronted Goose | GWFG | *Anser albifrons* |
| Green-winged Teal | GWTE | *Anas crecca* |
| Red-tailed “Harlan’s” Hawk | HALH | *Buteo jamaicensis harlani* |
| Herring Gull | HERG | *Larus argentatus* |
| Lesser Yellowlegs | LEYE | *Tringa flavipes* |
| Mallard | MALL | *Anas platyrhynchos* |
| Merlin | MERL | *Falco columbarius* |
| Mew Gull | MEGU | *Larus canus* |
| Northern Goshawk | NOGO | *Accipiter gentilis* |
| Northern Flicker | NOFL | *Colaptes auratus* |
| Northern Harrier | NOHA | *Circus cyaneus* |
| Northern Hawk Owl | NHOW | *Surnia ulula* |
| Northern Pintail | NOPI | *Anas acuta* |
| Orange-crowned Warbler | OCWA | *Oreothlypis celata* |
| Olive-sided Flycatcher | OSFL | *Contropus cooperi* |
| Osprey | OSPR | *Pandion haliaetus* |
| Pacific Loon | PALO | *Gavia pacifica* |
| Peregrine Falcon | PEFA | *Falco peregrinus* |
| Pine Grosbeak | PIGR | *Pinicola enucleator* |
| Red-breasted Merganser | RBME | *Mergus serrator* |
| Red-throated Loon | RTLO | *Gavia stellata* |
| Rusty Blackbird | RUBL | *Euphagus carolinus* |
| Sandhill Crane | SACR | *Grus canadensis* |
| Semipalmated plover | SEPL | *Charadrius semipalmatus* |
| Sharp-shinned Hawk | SSHA | *Accipiter striatus* |
| Solitary Sandpiper | SOSA | *Tringa solitaria* |

| | | |
|---|---|---|
| Spotted Sandpiper | SPSA | *Actitis macularius* |
| Surf Scoter | SUSC | *Melanitta perspicillata* |
| Swainson's Thrush | SWTH | *Catharus ustulatus* |
| Tree Swallow | TRES | *Tachycineta bicolor* |
| White-crowned sparrow | WCSP | *Zonotrichia leucopyrys* |
| White-winged Crossbill | WWCR | *Loxia leucoptera* |
| Yellow-rumped Warbler | YRWA | *Setophaga coronata* |
| *Mammals* | | |
| Beaver | Beaver | *Castor canadensis* |
| Black Bear | Black Bear | *Ursus americanus* |
| Lynx | Lynx | *Lynx canadensis* |
| Mink | Mink | *Mustela vison* |
| Moose | Moose | *Alces alces* |
| Red Squirrel | Red Squirrel | *Tamiasciurus hudsonicus* |
| Gray Wolf | Gray Wolf | *Canis lupus* |

**Appendix 4. Beginning and ending points of segments used in analysis of responses and detections of non-target species during a 2013 Northern Goshawk nesting survey on portions of three rivers on Kanuti National Wildlife Refuge, Alaska.**

| Survey locations and comparisons | Segment No. | Beginning point | | Ending point | |
|---|---|---|---|---|---|
| Kanuti River Responses | 1 | 66.220868 | -151.416235 | 66.171539 | -151.604473 |
| | 2 | 66.174052 | -151.611564 | 66.189570 | -151.825591 |
| | 3 | 66.192420 | -151.824399 | 66.213880 | -152.093844 |
| Kanuti River Detections | 1 | 66.220868 | -151.416235 | 66.166733 | -151.577539 |
| | 2 | 66.167291 | -151.585778 | 66.189570 | -151.825591 |
| | 3 | 66.192420 | -151.824399 | 66.213880 | -152.093844 |
| South Fork/ Jim Rivers Responses | 1 | 66.783790 | -151.12826 | 66.662380 | -151.47802 |
| | 2 | 66.662080 | -151.4863 | 66.613980 | -151.64897 |
| | 3 | 66.621550 | -151.64700 | 66.581670 | -151.91254 |
| South Fork/ Jim Rivers Detections | 1 | 66.783790 | -151.12826 | 66.673310 | -151.46376 |
| | 2 | 66.673310 | -151.46376 | 66.617890 | -151.65927 |
| | 3 | 66.614170 | -151.65697 | 66.581670 | -151.91254 |